# Appendix A

# Risk Assessment Methodology

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# Acronyms and Abbreviations

| | |
|---|---|
| CZM | Office of Coastal Zone Management |
| DCAMM | Division of Capital Asset Management and Maintenance |
| DCR | Department of Conservation and Recreation |
| DMP | Drought Management Plan |
| EOEEA | Executive Office of Energy and Environmental Affairs |
| EMAP | Emergency Management Accreditation Program |
| EPA | Environmental Protection Agency |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| FRCOG | Franklin Regional Council of Governments |
| NCDC | National Climate Data Center |
| NCEI | National Centers for Environmental Information |
| NE CASC | Northeast Climate Adaptation Science Center |
| NFIP | National Flood Insurance Program |
| NOAA | National Oceanic and Atmospheric Administration |
| PMT | Project Management Team |
| SFHA | Special Flood Hazard Areas |
| SLOSH | Sea, Lake, and Overland Surges from Hurricanes |

# Risk Assessment Methodology

## 1.1 Introduction

This document describes AECOM's methodologies for addressing the following natural hazards as part of the risk assessment update for the 2018 State Hazard Mitigation and Climate Adaptation Plan:

- Primary Climate Change Interaction: Changes in Precipitation
  - Inland Flooding (Including Dam Overtopping)
  - Drought
  - Landslide
- Primary Climate Change Interaction: Sea Level Rise
  - Coastal Flooding
  - Coastal Erosion
  - Tsunami
- Primary Climate Change Interaction: Rising Temperatures
  - Average/Extreme Temperature
  - Wildfires
  - Invasive Species
- Primary Climate Change Interaction: Extreme Weather
  - Hurricanes/Tropical Storms
  - Severe Winter Storm/Nor'easter
  - Tornadoes
  - Other Severe Weather
- Non-Climate Influenced Hazards
  - Earthquake

It also summarizes the plan's approach to incorporating technological and human-caused hazards.

The overarching goal for the risk assessment is the completion of a statewide risk assessment update that is consistent with all planning requirements outlined in 44 CFR 201.4 (see Attachment A) and integrates climate change impacts. The assessment includes a review of each hazard and potential risk and impacts on five key sectors: population, government, built environment, natural resources and environment, and economy. It also includes maps, tables, graphics, and/or other visual resources.

## 1.2 Key Assumptions

This document is a living document that was refined during the process of preparing the risk assessment based on the receipt and application of referenced datasets. For many of the hazards discussed below, some data utilized in the analysis has not changed significantly since the 2013 State Hazard Mitigation Plan. For those hazards whose underlying data has not changed, updates were primarily limited to data interpretation and inclusion of climate change analysis as appropriate. The asset data required for exposure and vulnerability analysis was derived from existing data provided by state agencies, as well as the State Agency Vulnerability Assessment Survey Tool that was developed as a part of this project. Additional asset data collection efforts were not conducted.

For the purposes of climate change analysis, the baseline year was defined as 2017. For hazards that are likely to be impacted by climate change, the vulnerability and risk assessment was conducted for the following time horizons: 2030, 2050, 2070, and 2100. Hazards likely to be impacted by climate change are: inland flooding, drought, coastal flooding, coastal erosion, tsunami, average/extreme temperature, wildfires, invasive species, hurricanes/tropical storms, and severe winter storm/nor'easter.

## 1.3 Risk Assessment Methodology

The sections below summarize the methodology for the risk assessment of each hazard encompassed in this plan. The 2018 hazard profiles are based on a wide range of information and data, including best available science and most current information on hazards, impacts, and the vulnerability of jurisdictions. The primary data collection window for this plan was from May 1, 2017 through August 18, 2017. In some sections, supplemental data was integrated into the plan for the purpose of capturing some of the significant weather events that occurred in the winter of 2017-2018 as well as other data that became available following the primary data collection window.

State facilities data used in the risk assessment were provided by the Division of Capital Asset Management and Maintenance (DCAMM). The Project Management Team (PMT) directed the revision of each hazard profile to include significant hazard events that have occurred since the last plan update, added new hazard zone maps, incorporated the likely impacts of climate change on each hazard, and updated other information as necessary. Subject-matter experts from various disciplines provided relevant data, including updated studies and reports, and reviewed and updated the completed hazard profiles. This expert review enhanced the accuracy and relevance of information, validated the criteria used to assess vulnerability, and enabled conformity with federal requirements. Extensive GIS data from state, regional, and local sources were utilized.

Applicable state mitigation planning requirements and Emergency Management Accreditation Program (EMAP) standards for each hazard are identified by superscript numbers and letters, respectively. These number and letter references correlate to text in Attachment A, State Mitigation Planning Requirements for Risk Assessments, and Attachment B, Emergency Management Standards (EMAP).

## 1.4 Primary Climate Change Interaction: Changes in Precipitation

### 1.4.1 Inland Flooding (Including Dam Overtopping)

#### Brief Summary of 2013 Methodology[1]

To assess the Commonwealth's exposure to the riverine flood hazard, an analysis was conducted with the most current floodplain boundaries. The A-Zone (1 percent annual change flood event) and X500-Zone (0.2 percent annual change flood event) were used. Using ArcMap GIS software, this data was overlaid with the asset data, and the appropriate flood zone determination was assigned. The newest Federal Emergency Management Agency (FEMA) Flood Insurance Risk Maps (FIRM)s were used in this analysis, including preliminary FIRMs provided by the Department of Conservation and Recreation (DCR). Where FIRMs were not available, Quality 3 (Q3) data was used. At the time of the analysis, Franklin County did not have FIRMs or Q3 data; however, a digital floodplain layer that had been developed by the Franklin Regional Council of Governments (FRCOG) was available and used for the analysis. This layer only includes the floodplain in those communities along the Connecticut River. The flood data used for the risk assessment is listed in Table 4-1 of Chapter 4.

#### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

The methodology described in Section 1.4.1.1 was repeated using the most recently available flood data. AECOM broke out range of potential losses based on the flood zone in which the

asset is located. National Flood Insurance Program (NFIP) data on policies, claims, and repetitive loss properties were also used to assess the historical impacts of flooding in each county. The assessment includes the impact on human health, specifically for at-risk populations, and how they could be more severely impacted by this hazard.[3,4,b]

Floodplain boundaries were overlain with the datasets identified in Section 1.4.1.3 in order to obtain a quantitative assessment of the population, government assets, natural resources that are vulnerable to flooding in each county. The economic impact of building replacement was also quantified.[a,b]

A total risk exposure was estimated for state-owned and leased buildings located in the 1- and 0.2-percent annual chance flood zones. This methodology assumed 100-percent loss to each structure and its contents if located in the defined flood hazard zones.[3,4,a]

NFIP policies, claims, and repetitive loss statistics by county were listed and mapped. NFIP repetitive loss and severe repetitive loss was also listed for the 15 municipalities with the highest number of repetitive loss properties. Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water. A qualitative discussion of vulnerable populations and health impacts was included to provide a more robust assessment of the vulnerable population.[a,b]

Dam overtopping is included in the inland flooding hazard section. The exposure and vulnerability to the dam overtopping hazard are discussed in a qualitative nature since the dam failure inundation maps and downstream hazard areas are considered sensitive information. Dam data and tables were updated with the most recent information available from the spatial layer maintained by Office of Dam Safety and from the 2016 National Inventory of Dams database.[5,a,b]

### Data Used[2,3,4,5,a,b]

- 2010 Population by Census Block
- 2016 National Inventory of Dams database
- Areas of Critical Environmental Concern (MassGIS data layer)
- BioMap2 Core Habitat (MassGIS data layer)
- BioMap2 Critical Natural Landscape (MassGIS data layer)
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- Government facilities (DCAMM data layer)

- Northeast Climate Adaptation Science Center (NE CASC) climate change data
- National Bridge Inventory data
- Special Flood Hazard Areas (SFHA) data

### 1.4.2 Drought

#### Brief Summary of 2013 Methodology[1]

Qualitative analyses were conducted for drought hazards.

#### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

AECOM referred to the Massachusetts Drought Management Plan (DMP) published May 2013, available updates to the DMP, and to the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), Drought Management website, for the most recent data.[a,b] AECOM included a qualitative discussion of likely changes to drought conditions under climate change based on climate change data provided by University of Massachusetts, Amherst.

The risk assessment includes a qualitative discussion of the impact of drought on population, including the impact of the hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions was described.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Data Used[2,3,4,5,a,b]

- Environmental Protection Agency Green Infrastructure: Build Resiliency to Drought website
- Massachusetts Drought Management Plan, May 2013 (and any available updates)
- EOEEA, Drought Management website
- EOEEA, Precipitation Database
- NE CASC climate change data
- U.S. Drought Monitor

### 1.4.3 Landslide

#### Brief Summary of 2013 Methodology[1]

In an attempt to estimate the Commonwealth's vulnerability to the landslide hazard, the Geology-Landslide Incidence and Susceptibility GIS layer from National Atlas was used to

coarsely define the general landslide susceptible area (Godt, 2001). The asset data (population, building stock, and critical facilities) [3,4,b] were used to support an evaluation of assets exposed and the potential impacts and losses associated with this hazard. To determine what assets are exposed, available and appropriate GIS data was overlaid upon the hazard area. A total risk exposure was estimated for assets located in the high incidence or high susceptibility zones. This methodology assumes 100-percent loss to each asset and its contents if located in the defined hazard zones. The limitations of this data set and analysis are recognized and are only used to provide a general estimate until higher resolution data is available Commonwealth-wide.

### Methodology for 2018 Plan Update[1]

AECOM utilized a similar methodology to the previous plan, based on the Slope Stability Map of Massachusetts, published in 2013. The map highlights three levels of slope instability: unstable, moderately unstable, and low instability. These layers were overlaid with asset data (population, building stock, and DCAMM facilities) to support an evaluation of assets exposed and the potential impacts and losses associated with this hazard. For the sake of conservative analysis, the methodology assumes 100 percent loss to each asset and its contents if the asset is located in any of the three zones of instability described above. Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

### Assumptions

AECOM assumes all data sources described below will be available when analysis is conducted. No additional assumptions have been identified at this time.

### Data Used [2,3,4,5,a,b]

- 2010 Population by Census Block
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- NE CASC climate change data
- National Bridge Inventory data
- Slope Stability Map of Massachusetts (Massachusetts Geological Survey)
- State facilities (DCAMM data layer)

# 1.5 Primary Climate Change Interaction: Sea Level Rise

## 1.5.1 Coastal Flooding

### Brief Summary of 2013 Methodology[1]

A spatial analysis was conducted using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model provided by the FEMA Risk Analysis Team to assess the Commonwealth's exposure to hurricane storm surge. Using ArcMap GIS software, the SLOSH zones were overlaid with asset data and the appropriate SLOSH zone determination (categories one through four) was assigned. The Hurricane Category 4 SLOSH depth grids provided by FEMA were imported into the Hazus-MH flood model and the potential losses were estimated for the state-owned and leased facilities. The coastal hazard was discussed qualitatively using available studies since the projected sea level rise inundation and depth grids were not available in time to conduct a quantitative analysis for the Commonwealth.

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Similar to the methodology for inland flooding, FEMA data was used to estimate assets at risk.[3,a,b] The A-Zone and V-Zone (1 percent annual change flood event) and X500-Zone (0.2 percent annual change flood event) were used in the quantitative analysis of vulnerable people, government assets, and economic exposure. AECOM used projected future flood maps from the NOAA Coastal Services Center, as well as water elevation data from the NE CASC, to analyze future conditions.[2,5] The impacts of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions were described.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water. Data derived from the National Climate Data Center Storm Events Database was used to update records of coastal flood events.[a,b]

### Data Used[2,3,4,5,a,b]

- 2010 Population by Census Block
- Areas of Critical Environmental Concern (MassGIS data layer)
- BioMap2 Core Habitat (MassGIS data layer)
- BioMap2 Critical Natural Landscape (MassGIS data layer)
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)

- FEMA Special Flood Hazard Areas (SFHA)
- General Building Stock Current Exposure (FEMA Hazus)
- Government facilities (DCAMM data layer)
- MassDOT-FHWA Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery
- NE CASC climate change data
- NOAA Coastal Services Center Sea Level Rise Data
- Northeast Climate Science Center Sea Level Rise Projections
- National Bridge Inventory data

### 1.5.2 Coastal Erosion

#### Brief Summary of 2013 Methodology[1]

Areas likely to be impacted by coastal erosion were identified using the MassDEP wetland spatial layer.[1] Assets within those areas were evaluated to determine risk.[3] Also, the Massachusetts Ocean Resources Information System Shoreline Change Browser was used to gain a better understanding of shoreline changes over time. Sea level rise projections were also considered.

#### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Shoreline change data from the Massachusetts Office of Coastal Zone Management (CZM) was used for the coastal erosion hazard assessment.[2,5] AECOM also referred to the Massachusetts Coastal Erosion Commission Final Report and Recommendations (December 2015) for additional information and findings. ("The Commission was asked to evaluate erosion levels since 1978 and assess the resulting financial damage to property, infrastructure, and beach and dune resources,[3,b] and to estimate the likely cost of damages over the next 10 years under current conditions, regulations, and laws.").[3,c,d] The impacts of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions were described.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Data Used[2,3,4,5,a,b]

- Critical state facilities (DCAMM data layer)
- CZM shoreline change data

- Government facilities (DCAMM data layer)
- Massachusetts Coastal Erosion Commission Final Report and Recommendations, December 2015
- MassDOT-FHWA Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery
- NE CASC climate change data

### 1.5.3 Tsunami

#### Brief Summary of 2013 Methodology[1]

Tsunami inundation areas are not available for the Commonwealth. In an attempt to estimate the Commonwealth's vulnerability to the tsunami hazard, a one-mile buffer from the coast was used to define the area exposed and thus vulnerable.[3,4,a]

#### Methodology for 2018 Plan Update[1]

Similar as in the 2013 SHMP, a one-mile buffer from the coast was used to define the area exposed and vulnerable to the tsunami hazard. The impacts of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions were described.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Data Used[2,3,4,5,a,b]

- 2010 Population by Census Block
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- DCAMM facility inventory
- Government facilities (DCAMM data layer)
- MA Hurricane Surge Inundation Zones
- NE CASC climate change data
- NOAA National Tsunami Hazard Mitigation Plan Tsunami Inundation Maps
- National Bridge Inventory data
- Shoreline data

# 1.6 Primary Climate Change Interaction: Rising Temperatures

## 1.6.1 Average/Extreme Temperature

### Brief Summary of 2013 Methodology[1]

Qualitative analyses were conducted for the extreme temperature hazard.

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

The methodology for average/extreme temperature hazard consisted of compiling data on the historic average temperature and the recurrence of extreme temperature and incorporating future average and extreme temperature projections based on available climate change data.[2] A quantitative analysis of socioeconomic factors that serve as indicators of the vulnerability of the population was conducted. Statistics on hospital and emergency department visits available from the Massachusetts Environmental Public Health Tracking website were also used. The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water. [a,b]

### Data Used[2,3,4,5,a,b]

- 2010 population by county (Census data)
- Massachusetts Environmental Public Health Tracking data
- MassDOT Assessment of Extreme Temperature Impacts on MassDOT Assets
- National Weather Service
- NE CASC climate change data
- NOAA data on property damage due to winter storms and extreme cold
- NOAA's Storm Events Database
- NOAA's National Centers for Environmental Information (NCEI) data

## 1.6.2 Wildfires

### Brief Summary of 2013 Methodology[1]

For the purposes of this risk assessment, the interface and intermix obtained through the SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison defines the wildfire hazard area (Radeloff et al., 2011). The wildfire hazard areas are based on the 2010

Census and 2006 National Land Cover Dataset and the Protected Areas Database. The high-, medium- and low-density interface areas were combined and used as the 'interface' hazard area and the high-, medium- and low-density intermix areas were combined and used as the 'intermix' hazard areas. The asset data (population, building stock and critical facilities) were used to support an evaluation of assets exposed and the potential impacts and losses associated with this hazard.[3,b] To determine what assets are exposed to wildfire, available and appropriate GIS data was overlaid upon the hazard area. A total risk exposure was estimated for assets located in the intermix and interface zones. This Methodology assumes 100-percent loss to each asset and its contents if located in the defined hazard zones.[4] The limitations of this analysis are recognized, and as such the analysis is only used to provide a general estimate.

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

The methodology used to prepare the hazard assessment for wildfires in 2013 was repeated, using the latest intermix and interface zones. The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

### Data Used[2,3,4,5,a,b]

- 2010 Population by Census Block
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- Estimated Potential Building Loss (FEMA Hazus)
- Government facilities (DCAMM data layer)
- Northeast Wildfire Risk Assessment Geospatial Work Group data
- National Bridge Inventory/MassGIS data layer
- University of Wisconsin-Madison, Silvis Lab - Wildland Urban Interface data
- USGS Post-Wildfire Debris-Flow Hazards data
- USGS Wildfire data

### 1.6.3 Invasive Species

#### Brief Summary of 2013 Methodology

N/A

#### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Sixty-nine plant species have been scientifically documented to be "Invasive," "Likely Invasive," or "Potentially Invasive" in Massachusetts by the Massachusetts Invasive Plant Advisory Group.[5] Invasive plant species (including marine species) in Massachusetts were identified using the most current data available.[a] Current state regulations were identified. The assessment included recommendations for managing invasive plants in the Commonwealth. AECOM evaluated the current prevalence of crop/forest pests and pathogens in the Commonwealth, and how climate change is likely to affect the presence of these threats and the damage they inflict.[4] The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of government facilities and sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Data Used[2,3,4,5,a,b]

- EOEEA invasive species data

## 1.7 Primary Climate Change Interaction: Extreme Weather

### 1.7.1 Hurricanes/Tropical Storms

#### Brief Summary of 2013 Methodology[1]

The Commonwealth selected historic events (tropical storm, and hurricane categories one through three) for simulation in Hazus-MH 2.1. If the historic storm was not in the Hazus database, the storm's characteristics were manually defined in Hazus-MH 2.1 using best available data. The Hazus-MH 2.1 wind model was run for the entire Commonwealth to obtain building wind-only potential loss estimates.

#### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Hazus-MH 4.0 and 2010 census data were used to update the basic analysis of the hurricane/tropical storm hazard in the 2013 plan.[5,a] Because new census data was not available at the time of the 2018 plan update, it was anticipated that this method would produce similar results as 2013. The assessment describes the impact of this hazard on human health, particularly

for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of government facilities and sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Data Used[2,3,4,5,a,b]

- 2010 Population (Census data)
- Areas of Critical Environmental Concern (MassGIS data layer)
- BioMap2 Core Habitat (MassGIS data layer)
- BioMap2 Critical Natural Landscape (MassGIS data layer)
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- Government facilities (DCAMM data layer)
- NE CASC climate change data.
- NOAA Historical Hurricane Tracker
- National Bridge Inventory data
- SLOSH Zones

### 1.7.2 Severe Winter Storm/Nor'easter

#### Brief Summary of 2013 Methodology[1]

A custom Nor'easter scenario was developed and incorporated into Hazus-MH 2.1 for the analysis. The Commonwealth selected the 1978 February Nor'easter as one of the most devastating Nor'easter events in their hazard history. The storm's characteristics were manually defined in Hazus-MH 2.1 using best available data. The maximum radius to maximum winds in Hazus-MH 2.1 is 93 and was utilized for this event. The wind model was run for the entire Commonwealth. To obtain both wind and surge results, the near-shore wave model was run for the census blocks along the coastline.[b] The census blocks selected for the analysis at minimum included all blocks within category one through four SLOSH zones. Initial water levels were obtained from the historic predicted normal tide levels from NOAA tide stations throughout the study region for the event. At that time, only building estimated potential losses were available from the Hazus-MH 2.1 surge model.[3]

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Because the exposure and vulnerability analyses of nor'easters conducted for the 2013 plan were based on historical events, the same tables were used in this plan. The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

### Data Used[2,3,4,5,a,b]

- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- FEMA Winter Storm-Related Declared Disasters by County
- Government facilities (DCAMM data layer)
- MEMA high snow areas data layer
- SLOSH Zones

## 1.7.3 Tornadoes

### Brief Summary of 2013 Methodology[1]

The number of historic tornado touch-downs in 25 miles was updated using the NOAA Storm Prediction Center's dataset through 2011 (2012 data was not available at the time of the 2013 Plan update). To calculate density, the ArcGIS kernel density tool was used. As was conducted in the 2010 hazard mitigation plan, tornado risk for the 2013 update was based on the probability of occurrence of past events.[2] To analyze how tornadoes could impact state facilities, critical facilities, and bridges, the DCAMM data was overlaid with the state's area of greatest historic tornado density.[3,b]

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

Using NOAA Storm Prediction Center's dataset (Tornado), recreated the methodology used in the 2013 plan update by overlaying DCAMM facility data with tornado density data. The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

### Data Used[2,3,4,5,a,b]

- ASCE Wind Load Zones data
- Building replacement cost value (FEMA Hazus)
- Critical state facilities (DCAMM data layer)
- FEMA Severe Storm Declared Disaster data
- Government facilities (DCAMM data layer)
- National Bridge Inventory data
- NE CASC climate change data
- NOAA NCEI data
- NOAA Storm Prediction Center's dataset (Tornado)

## 1.7.4 Other Severe Weather

### Brief Summary of 2013 Methodology[1]

#### High Winds/Thunderstorms

Massachusetts is divided into four wind zones, the limits of which are defined by the Massachusetts State Building Code Seventh Edition. Using ArcMap GIS software, this data was overlaid with the DCAMM facility data and the appropriate wind load zone determination was assigned to each facility.

### Methodology for 2018 Plan Update, Including Climate Change Projections[1]

#### High Winds/Thunderstorms

Using the most recent Massachusetts State Building Code, AECOM recreated the methodology described above by overlaying DCAMM facility data with hazard data. Existing and trends in seasonal and extreme precipitation, as well as future precipitation projections from the NE CASC data were discussed. The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

### Data Used[2,3,4,5,a,b]

- Massachusetts State Building Code (High Winds/Thunderstorms)
- DCAMM facility data

- NE CASC climate change data
- NOAA NCEI data
- FEMA Severe Storm Declared Disasters

## 1.8 Non-Climate Influenced Hazards

### 1.8.1 Earthquake

#### Brief Summary of 2013 Methodology[1]

A probabilistic assessment was performed using Hazus-MH 2.1 to analyze the earthquake hazard estimated potential losses (100-, 500- 1,000-and 2,500-year mean return period losses). For this analysis, available NEHRP soil data in portions of Franklin, Hampden, and Hampshire counties provided by the State Geologist, Mr. Stephen Mabee, was incorporated into Hazus-MH 2.1 and used for all analyses. Damages and loss due to liquefaction, landslide, or surface fault rupture were not included in this analysis. Estimated damages to the general building stock were generated at the Census-tract level.

#### Methodology for 2018 Plan Update[1]

Ran a new probabilistic scenario using Hazus-MH 4.0, utilizing current/existing soil data files, with a standard level 1 analysis.[4,5,a] The assessment describes the impact of this hazard on human health, particularly for at-risk populations, and how they could be more severely impacted by this hazard under future conditions.[3,4,b] Qualitative information derived from the resilient MA Clearinghouse and other state sources was used to describe the vulnerability of sectors of the built environment, including agriculture, energy, public health, transportation, and water.[a,b,4,5]

#### Assumptions

AECOM assumes all data sources described below will be available when analysis is conducted. No additional assumptions have been identified at this time.

#### Data Used[2,3,4,5,a,b]

- National Earthquake Hazard Reduction Program soil classifications
- Estimated number of injuries and casualties (FEMA Hazus)
- Estimated Shelter Requirements (FEMA Hazus)
- Building-Related Economic Loss Estimates (FEMA Hazus)
- Transportation and Utility Losses (FEMA Hazus)

## 1.9 Technological and Human-Caused Hazards Adopted by Reference

Technological and human-caused hazards were not included in the scope of this analysis. However, in order to assist with EMAP accreditation, the 2018 plan contains a brief section summarizing the nature of these hazards and the applicable planning documents for each. Incorporating these additional documents by reference reduces the redundancy of the document and streamlines EMAP's review process. The applicable planning documents addressed in this manner include:

- Massachusetts Threat Hazard Identification and Risk Assessment (THIRA)
- Comprehensive Emergency Management Plan
- Nuclear Plans
- Dam Emergency Action Plans

# Attachment A: State Mitigation Planning Requirements for Risk Assessments

[1] **S3. 44 CFR §201.4(c)(2)(i)** ***Does the risk assessment include an overview of the type and location of all natural hazards that can affect the state?***

- The plan must include a current summary of the natural hazards that can affect the state. The summary must include information on location, extent, and previous occurrences for each natural hazard, using maps where appropriate.
- If any commonly recognized natural hazards are omitted, the plan must provide an explanation.

[2] **S4. 44 CFR §201.4(c)(2)(i)** ***Does the risk assessment provide an overview of the probabilities of future hazards?***

- The risk assessment must provide a summary of the probability of future hazard events that includes projected changes in occurrences for each natural hazard in terms of location, extent, intensity, frequency, and/or duration.
- Probability must include considerations of changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards.

[3] **S5. 44 CFR §§201.4(c)(2)(ii) and 201.4(c)(2)(iii)** ***Does the risk assessment address the vulnerability of state assets located in hazard areas and estimate the potential dollar losses to these assets?***

- The risk assessment must include an analysis of the potential impacts of hazard events to state assets and a summary of the assets most vulnerable to the identified hazards. These assets may be located in the identified hazard areas or affected by the probability of future hazard events.
- The risk assessment must estimate potential dollar losses to state assets located in identified hazard areas.

[4] **S6. 44 CFR §201.4(c)(2)(ii) and §201.4(c)(2)(iii)** ***Does the risk assessment include an overview and analysis of the vulnerability of jurisdictions to the identified hazards and the potential losses to vulnerable structures?***

- The risk assessment must provide a current summary of the most vulnerable jurisdictions based on the state, local, and tribal, as applicable, risk assessments. Vulnerability must be analyzed in terms of:

  - Jurisdictions most threatened by the identified hazards (based on hazard location, extent, and probability).
  - Jurisdictions most susceptible to damage and loss from hazard events related to populations and assets (such as, structures, infrastructure, critical facilities, and systems). These populations and assets may be located in the identified hazard areas or affected by the probability of future hazard events.

- The risk assessment must include a summary of the potential losses to the identified vulnerable structures based on estimates in the local risk assessments as well as the state risk assessment.
- If the state is interested in an increased Federal cost share under the FMA program, the risk assessment must address repetitive loss (RL) and SRL properties.

[5] **S7. 44 CFR §201.4(d)** ***Was the risk assessment revised to reflect changes in development?***

- The plan must provide a summary of the changes in development that have occurred or are projected to occur in hazard prone areas based on the state, local, and tribal, as applicable, risk assessments, specifically:
  - Changes in land use and the built environment;
  - Changes in population demographics that may affect vulnerability to hazard events; and
  - Changes to the vulnerability of state-owned or operated buildings, infrastructure, and critical facilities.

# Attachment B: Emergency Management Standards (EMAP)

## 4.1: Hazard Identification, Risk Assessment and Consequence Analysis

### Overview

An Accredited Emergency Management Program has a Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis.

[a]**4.1.1** The Emergency Management Program identifies the natural and human-caused hazards that potentially impact the jurisdiction using multiple sources. The Emergency Management Program assesses the risk and vulnerability of people, property, the environment, and its own operations from these hazards.

[b]**4.1.2** The Emergency Management Program conducts a consequence analysis for the hazards identified in Standard 4.1.1 to consider the impact on the following:

1. public;
2. responders;
3. continuity of operations including continued delivery of services;
4. property, facilities, and infrastructure;
5. environment;
6. economic condition of the jurisdiction; and
7. public confidence in the jurisdiction's governance.

[c]**4.1.3** The Emergency Management Program has a method and schedule for evaluation, maintenance, and revision of its Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis identified in Standard 4.1.1.

## 4.2: Hazard Mitigation

### Overview

An Accredited Emergency Management Program has a mitigation program that regularly and systematically utilizes resources to mitigate the effects of emergencies/disasters associated with the risks identified in the HIRA.

[d]**4.2.1** The Emergency Management Program has a plan to implement mitigation projects and sets priorities based upon loss reduction. The plan:

1. is based on the natural and human-caused hazards identified in Standard 4.1.1 and the risk and consequences of those hazards;
2. is developed through formal planning processes involving Emergency Management Program stakeholders; and
3. establishes interim and long-term strategies, actions, goals and objectives.

[e]**4.2.2** The Emergency Management Program documents project ranking based upon the greatest opportunity for loss reduction and documents how specific mitigation actions contribute to overall risk reduction.

[f]**4.2.3** The Emergency Management Program has a process to monitor overall progress of the mitigation activities and documents completed initiatives and their resulting reduction or limitation of hazard impact on the jurisdiction.

[g]**4.2.4** The Emergency Management Program, consistent with the scope of the mitigation program, does the following:

1. provides technical assistance in implementing applicable mitigation codes and ordinances;
2. identifies ongoing opportunities and tracks repetitive loss; and
3. participates in applicable jurisdictional, inter-jurisdictional and multi-jurisdictional mitigation efforts.

[h]**4.2.5** The Emergency Management Program has a method and schedule for evaluation, maintenance, and revision of the plan identified in Standard 4.2.1.

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